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Putnam, F. W., and Udin, B., 1953. Proteins in multiple myeloma. I Physicochemical studies of serum proteins., *J. Biol. Chem.*, 202: 727.
Putnam, F. W., and Hardy, Sarah. 1955. Proteins in multiple myeloma. III Origin of Bence-Jones protein., *J. Biol. Chem.*, 212: 361.
Reiner, Miriam, and Stern, K. G., 1953. Electrophoretic studies on the protein distribution in the serum of multiple myeloma patients., *Acta Haemat.*, 9: 19.
Rundles, R. W., Cooper, G. R., and Willett, R. W., 1951. Multiple myeloma. IV Abnormal serum components and Bence-Jones protein., *J. Clin. Invest.*, 30: 1125.

Identification of Basic Concepts of Chemistry Appropriate for Grade Seven

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Abstract. One of the greatest results of the increased popular interests in science has been the development of advanced high school science courses. These courses have necessitated the reexamination of junior high school science curricula. In line with this reconsideration the University High School of the State University of Iowa has developed a special junior high school science sequence to aid in this preparation.

The seventh grade science course is entitled Matter and serves as the foundation where basic concepts are learned. Those chemical concepts most effectively learned by this age group are: (1) the nature of matter (2) atomic theory and structure (3) periodicity of elements and the periodic chart (4) molecular theory (5) chemical bonding (6) valence and formula writing (7) ionization in solutions (8) concentrations of solutions (9) nature of acids, bases, and salts (10) elementary organic chemistry concepts.

Preliminary findings portend the success of this program.

Since the Russian achievements in space in October of 1957, educators in this country have begun serious reconsiderations of the adequacy of science programs which are to prepare students for participation in a society which is becoming more and more technologically and scientifically oriented. May Brodbeck has pointed out that the growing prestige of the scientist and his increasing role in social affairs as well as the use of the threat of new weapons by all sides in world diplomacy make science of special concern to both the reflective citizen and scientist. the layman, feeling the impact of science on his life far beyond the convenience of new gadgets and inventions begins to wonder just what man has wrought(1). This concern has manifested itself in serious reexaminations in education of the science curriculum itself.

The reexamination, in turn has resulted in positive action;

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Glenn Blough has noted that when one area of the curriculum is given special attention and emphasis with increased financial aid, more time allotment, and intensive considerations in many other ways, improvement is to be expected. In the past few years science has been receiving a lion's share of what has been available to education. There has been an urgency attached to science teaching that tends to overshadow other areas of the curriculum at all levels. Due to this concentrated effort, progress *has* been made(2).

This progress has taken place in four main areas((a) Direct financial assistance to college undergraduate and graduate students in the sciences; (b) assistance to science teachers through federally financed academic year, summer and in-service institutes; (c) increased allocations for facilities and equipment at the local, state, and federal level; and, (d) preparation and in strumentation of new curricula more suited to current demands and interests. This last area of progress is one of particular concern to the science department of the University High School of the State University of Iowa since U. High is a school in which experimentation leading toward curriculum improvement is always being carried on.

Since 1959 a new science curriculum revision has been underway in which we hope to utilize and build upon some of the more outstanding of the new courses of study developed by committees of nationally reknown scientists and science educators. The courses of this type which University High School is using are the following: The Pphysical Science Study Committee's course in physics; the biology course developed by the Biological Science Curriculum Study Committee of the American Institute of Biological Science; and the Chemical Bonds Approach chemistry course.

The more advanced nature of these courses demands a greater degree of subject-matter competence than the conventional junior high school general science sequence has formerly developed. In keeping with this demand, the junior high school curriculum was also revised, being divided into distinct subject-matter areas. The teachers for each of the three grades, seventh, eighth, and ninth, are especially prepared in the areas which each course stresses. The ninth grade course deals with physics and astronomy, the eighth grade course contains biology, and the seventh grade course, which is the foundation of the secondary science curriculum is entitled "Matter" and deals specifically with geology and chemistry.

In designing this course, no particular difficulties were encountered in developing the units dealing with topics in geology, because many appropriate course outlines and competent texts were available as guides. The development of an integrated, meaningful chemistry for students of this age level, however, presented several problems, the answer to many of which had to be found by experience. How much did the students already know about chemistry? How many misconceptions did they already hold? How much "real chemistry" can a twelve-year-old absorb? How shall this chemistry be presented?

The first year's experiences with the new course in the 1960-1961 school year pointed up areas of weakness in both content and method. One of the greatest deficiencies was found in the area of texts. There was none suitable for use at this age level, so one was written to correspond with and supplement the course as outlined.

The major problem in developing the course was identification of chemical concepts which could be assimilated by seventh grade students and would be valuable and necessary to them in their future science work in the remainder of the secondary curriculum. In this paper I wish to briefly discuss ten of these major concepts and comment on the presentation and implementation of some.

Before any of these concepts are discussed, perhaps the term "concept" as it is used in this paper should be clarified. Paul L. Dressel has commented that concepts may be defined as being abstractions which organize all objects and events into a smaller number of categories. These categories, in turn, can be organized into hierarchical systems, thereby extending organized knowledge. The term, concept, may be restricted to ideas descriptive of classes of objects or events. However, generalizations and principles may also be treated as concepts. Generalizations and principles differ from simple concepts in that the former state some kind of relationship between two or more abstractions, objects, or events, and the latter is a single class such as the term "light", or "force" (3). Here, the term concept shall be used in the broader sense—that referring to generalizations and principles.

The initial concept which is dealt with is the title of the course —Matter. We attempt to answer such questions as: What is matter? How big or small can something be and still be matter? Is there anything that does not fall within the realm of matter? How may matter be described? The answer to this last question constitutes an introduction to chemical and physical properties and the art of accurate observation and reporting. This is also the appropriate place for the introduction of the metric system as the most scientific method of measuring matter.

The purpose of the first concept described and its implications is to determine the differences in matter. The second concept stresses the similarities, this concept being that of the atom and its role as the "building block of matter." The development of the idea that all matter is composed of atoms leads naturally to the question, "Of what are atoms composed?" The development of the concept of atomic structure with students of this relatively young age is easier than it is with older students because this former group has one of the prime requisites for learning something of this unseen, abstract nature—a good imagination. We attempt to fix their mental image by having the students make atomic models from any materials they consider appropriate such as wire, clay, and styrofoam.

The concept of periodicity follows naturally this construction of atomic models. If the models are made to scale, the periodicity of atomic diameter may be easily seen; if not, the arrangement by the number of electrons in the outer shell may be the sole criterion. When the students have arranged the elements in what thy consider a logical order, investigation of brief descriptions of the physical and chemical properties of the elements may serve to document their arrangement. Some of the brighter students find mention made of the idea of electro-negativity as a periodic property of elements and choose to investigate this relatively advanced concept on their own.

From single atoms we proceed to molecules as groups of atoms. This study is supplemented by the use of commercially-prepared as well as student-constructed molecular models and electron photomicrographs of actual molecules which are available. In this concept, the idea of size of molecules may be grasped by the students, because there are molecules they can *see* even though it is under intense magnification, whereas in discussing atoms, the concept of atomic size is almost incomprehensible.

Discussion of molecules brings up the question of how atoms happen to stick together to form these molecules, so this is the perfect location for the development of the concept of bonding and types of chemical bonds. Here, a concept which may be very complex is greatly simplified by presenting only two sides of a many-sided problem. The general class investigates and learns about only the two ends of the bonding continuum—electrovalent compounds and covalent compounds. Some of the bright students may study the differing degrees of polarity of bonding, but this is beyond the comprehension of most of the class.

The concept of valence is utilized primarily as a tool in writing correct chemical formulas. The student becomes familiar with the valences of common metals, non-metals, and radicals. The idea of some elements having multiple valences under different conditions is pointed out, and it is usually not necessary to go into this in detail.

Ionization in solution is a concept easily demonstrated by the conductivity of different solutions. Here again, the twelve-year-old imagination is a valuable asset. It seems to be much easier for them to "see" the ionic arrangement that seems to exist in ionic solutions than it is for the older students.

In the study of solutions, concentration is an important factor. Students in the seventh grade can well understand the idea of concentration expressed as normality, molarity, and molality. Essential to these expressions of concentration, of course, is the concept of the gram molecular weight and Avagaro's Number. By using the appropriate calculations and the periodic chart with which they are already familiar, they can prepare in the laboratory solutions of given concentration for their own use in further experiments and exercises.

The transition from the discussion of solutions and their characteristics to the nature of acids, bases, and salts is readily apparent, since these characteristics are most commonly studied in solution. The differentiation between these compounds is made quite simply by determining the generalities concerning their chemical compositions—what it is that characterizes each chemically—and their action on various indicators. The study of pH, its meaning and implications, are again left to the brighter students in the class as enrichment material, since it is really too difficult for the majority of the students.

Finally, the student is introduced to organic chemistry in this course. The use of models make visualization of the molecular structure of organic compounds particularly easy. The differences between organic and inorganic compounds is stressed, and they may be observed in the laboratory in student exercises in the comparison of such properties as boiling and melting point, conductivity, relative solubility in organic and inorganic solvents, and the range of odors and colors. An area of organic chemistry which the students particularly enjoy is the working out and naming of possible isomers of hydrocarbons.

Near the end of the year the structures and properties of carbohydrates, fats, and proteins are introduced in preparation for the students' next science course—biology. These compounds are too complex to investigate intensively, but some of their standard tests and reactions may be studied very profitably. Students whose interests tend to be oriented in the direction of more practical chemistry find areas such as coal, petroleum and syn-

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thetics to be a particularly interesting aspect of organic chemistry.

These are the main concepts in the course, and through their combination the course has been developed as indicated in the following outline.

Unit I. Introduction: Matter
Unit II. Atomic Structure and the Periodic Chart
Unit III. Elements and Compounds
Unit IV. Families of Elements
Unit V. Water and Solutions
Unit VI. Origin and Structure of the Earth
Unit VII. Elements in the Earth's Crust
Unit VIII. Types and Formation of Mountains
Unit IX. Volcanoes and Earthquakes
Unit X. Destructive Forces
Unit XI General Characteristics of Organic Compounds
Unit XII. Hydrocarbons
Unit XIII. Hydrocarbon Derivatives
Unit XIV. Rocks and Minerals
Unit XV. Optional Additional Units—(could be used as enrichment material or in a faster class)

A. Rubber and Synthetics
Suggested placement: following Unit XIII

B. Crystals and Crystallography
Suggested placement: preceding Unit XIV or following Unit V.

*C. Oceans
Suggested placement: following or included in Unit X.

*D. Fossils
Suggested placement: following or preceding Unit VI.

*E. Atmosphere and Climate
Suggested placement: preceding Unit X.

* No unit outline of these topics has been prepared because these are student-suggested topics, and they investigated these areas by their own plan (4).

One may well wonder after hearing this brief treatment of the major conceptual points of a seventh grade chemistry course, in the final analysis, just how much chemistry do these students learn? Is it worth the time and effort to present a course at this level which has traditionally been reserved for the junior or senior year in high school? We feel that it is. First there is the value gained from the enthusiasm for "real" science that this course seems to generate in students who would be bored by the repetitious nature of a general science course that had no approach different from that they have experienced in six previous years of elementary work. Secondly, although the course has not been in operation long enough to gether extensive test data, the limited data already available are quite favorable. The Anderson Chemistry Test administered at the end of the first year's operation gave the following results. Of 30 seventh grade students, the student with the highest score was placed at the 67th percentile on the national norm; the student with the lowest score was placed at the 4th percentile. The median score was at the 19th percentile, and the interquartile range was from the 13th to the 33rd percentile.

Superficially these scores appear to be quite low; however, it should be remembered that these scores were standardized on students four years older than these seventh grade students. Specifically, the median chronological age of the students on whom the test was standardized was 17 years, 6 months, while that of the seventh graders was only 13 years. On the basis of this comparison, the seventh grade students' performance was quite creditable.

Keeping in mind the student enthusiasm for science as well as the more quantitatively expressed achievement scores, we feel that this course which includes development of the chemistry concepts previously discussed as well as some in earth science serves to accomplish the initial purpose of the course. This purpose is to prepare the student, in attitude as well as in subject matter and laboratory competence, for further profitable and rewarding work in the sciences.

Literature Cited

1. Brodbeck, May, "The Nature and Function of the Philosophy of Science"; Herbert Feigl and Mary Brodbeck, *Readings in the Philosophy of Science,* Appleton-Centure-Crofts, Inc., New York, 1953, p. 3.
2. Blough, G. O., "Improving the Science Program", *Educational Leadership,* 19, 220 (1962)
3. Dressel, Paul L., "How the Individual Learns Science"; *Rethinking Science Education; 59th Yearbook of the National Society for the Study of Education,* Part I., Univ. of Chicago Press, Chicago, 1960, p. 39.
4. Yager, R. E., Editor, *Secondary Science Curriculum,* University Printing, State University of Iowa, Iowa City.